3.5 GEOLOGY/SOILS

This section is derived from a number of existing documents, including the Geotechnical Data Report for the SELRP (URS 2012, Appendix M), the SAP (M&N 2013, Appendix A), the 2012 RBSP EA/EIR (SANDAG 2011), and the *San Elijo Lagoon Enhancement Plan* (County of San Diego 1996). Section 3.3 (Oceanography/Coastal Processes) addresses beach conditions and sand transport, including erosion of beach sand; so these are not addressed here.

3.5.1 AFFECTED ENVIRONMENT

The project study area is located within the coastal plain of the Peninsular Ranges Geomorphic Province and consists of marine and nonmarine terraces dissected by San Elijo Lagoon. Coastal bluffs extending north and south of the lagoon range up to 100 feet in height and can be steeply sloped cliffs along the coast in a series of wave-cut terraces.

San Elijo Lagoon Study Area

Historic Geologic Setting

San Elijo Lagoon was formed during a period of sea level lower than present day, when the shoreline was farther to the west, and rivers and creeks in the San Diego area cut channels downward and extending offshore. This formed steep canyons and, as sea level rose through the Holocene period, rivers backfilled their channels. San Elijo Lagoon is within the backfilled former channel of Encinas Creek. Present sediments within the lagoon were deposited within a shallow intertidal setting with some alluvial deposition during floods or other periods of high runoff from the surrounding valleys. At the inlet of the lagoon, a sill of rock of the Delmar Formation influences shoaling, inlet stability, and tidal exchange between the ocean and lagoon (URS 2012).

Steep bluffs border the lagoon on the north and south sides. These bluffs are generally composed of tertiary marine deposits of the Delmar and Torrey sandstone formations, topped by Lindavista red sandstone formations (County of San Diego 1996). The Delmar Formation is generally described as dusky yellowish-green sandy claystone interbedded with medium-gray coarse-grained sandstone (California Department of Conservation, Division of Mines and Geology 1996). The San Elijo Lagoon Enhancement Plan identifies this stratum as overlain by a 5- to 25-foot layer of mudstone, with a number of fossiliferous (brackish water mollusks) beds occurring near the lagoon toward the top of the formation. The Torrey Sandstone Formation overlays the Delmar Formation, and is white to light brown in color and medium- to coarse-grained in texture. The Lindavista Formation caps the terraces and is a reddish brown, interbedded sandstone and conglomerate.

Generally, sediment in the lagoon is characterized as alluvium and colluviums (California Department of Conservation, Division of Mines and Geology 1996), consisting of unconsolidated silt, clay, sand, and gravel. The Natural Resources Conservation Service (NRCS) Soil Survey classifies the majority of the west and central lagoon basins as lagoon waters (LG-W). Other NRCS soil classifications located throughout the southern edge of the lagoon and the east basin generally include (NRCS 2014):

- Chino silt loam (CkA), saline, 0–2 percent slopes
- Corralitos loamy sand (CsC), 5–9 percent slopes
- Corralitos loamy sand (CsD), 9–15 percent slopes
- Huerhuero loam (HrE2), 15–30 percent slopes, eroded
- Loamy alluvial land Huerhuero complex (LvF3) 9–50 percent slopes, severely eroded
- Terrace escarpments (TeF)
- Tidal flats (Tf)

Cretaceous metavolcanic and granitic rock underlay the lagoon, with approximately 150 feet of alluvial clay and silts overlaying this foundation (County of San Diego 1996). Sand is also mixed in with this sedimentary layer. Specific soils testing of the lagoon sediments was conducted to determine the specific extent of clays and silts compared to sand in order to identify potential materials disposal needs and reuse opportunities. These studies are described in more detail below.

Subsurface Testing

Subsurface explorations at the lagoon were conducted between fall 2011 and spring 2012 to help determine the most effective materials disposal scenario and the potential for beneficial reuse of materials from the SELRP. The results of this effort are detailed in the Geotechnical Data Report (Appendix M) and the SAP Report and are summarized below. The SAP (Appendix A) indicates that material excavated from the overdredge pit location (below approximately 2–3 feet bgs) is likely suitable for placement on beaches or in the nearshore based on physical properties related to grain size and material chemistry based on information generated to date. These materials consist, on average, of 10 percent fines and are classified as sand. The age of this sediment layer suggests it has been removed from modern sources of pollution. Additional evaluation of the preferred alternative and placement option with these agencies may be required to obtain a final compatibility determination if changes to the project or to on-site conditions occur prior to construction, or if significant time delays occur in project processing. Additional evaluations would consist of supplemental geotechnical borings and testing for material grain size and chemistry.

Other samples collected show two distinct sedimentary layers generally extending through the lagoon basins, including (1) a relatively thin clay/silt layer extending from the ground surface to average depths of approximately 2 to 4.5 feet bgs, and (2) silty sand to poorly graded sand to the maximum depth of the borings. The silty clay to clayey silt layer was mostly classified as CH (clay, high plasticity) and ML (silt, low plasticity) type soils, according to the Unified Soil Classification System. This layer was generally continuous through the lagoon, but varied in thickness and depth, extending to approximately 9 feet thick in the east basin and thinning out substantially toward the west, even disappearing completely in parts of the west basin. Below this clay/silt layer, loose to medium dense, grey to dark grey silty sand to poorly graded sand was encountered to depths up to approximately 31.5 feet bgs. These sandy deposits were primarily fine-grained sand with a small percentage of medium-grained sand and are classified as SM (silty sand), SM-SP (poorly graded sand), and SP type soils. Shell fragments and sparse pebbles and gravel were observed in some of the borings. No hard substrate was encountered (e.g., gravel or bedrock) in any of the boring locations (URS 2012).

Faulting and Seismicity

The project study area is located in a moderately active seismic region of southern California subject to ground-shaking from nearby fault zones. The Rose Canyon fault zone is an active offshore/onshore fault capable of generating an earthquake of magnitude 7.2 on the Richter scale (Ninyo & Moore 2012). The fault zone lies partially offshore as part of the Newport/Inglewood fault zone and parallels the northern coastline of the San Diego region within approximately 2 to 6 miles until coming ashore near La Jolla Shores. The onshore segment trends through Rose Canyon, through Old Town San Diego, and appears to die out in San Diego Bay (Abbott 1989). In the event of an earthquake, the Rose Canyon fault zone, which occurs at a distance of approximately 2.5 miles from the study area, can result in moderate to severe groundshaking in the coastal area of northern San Diego County.

The project area is not located within a Fault-Rupture Hazard Zone as delineated by the California Geological Survey under the Alquist-Priolo Earthquake Fault Zoning Act (California Department of Conservation 2012).

Liquefaction

Liquefaction occurs primarily in saturated, loose, fine- to medium-grained soils in areas where the groundwater table is generally 50 feet or less below the surface. When these sediments are shaken during an earthquake, a sudden increase in pore water pressure causes the soils to lose strength and behave as a liquid. The soils and geologic conditions associated with San Elijo Lagoon are susceptible to liquefaction due to seismic shaking (Ninyo & Moore 2012).

Erosion

Historically, activities occurring throughout the watershed, such as roads, agriculture, and construction, resulted in erosion and suspended solids in runoff. These solids subsequently settled out as sedimentation in the lagoon. Escondido Creek and, to a lesser extent, La Orilla Creek, are the historic principal transporters of alluvial sediment. Erosion of gullies also provided a substantial historic source of sediment for the lagoon. Much of the sediment delivered to the lagoon due to erosion was from past activities when construction and agricultural activities were high. The rate of sedimentation has decreased with buildout of the watershed and agricultural areas, as well as the initiation of conservation practices (County of San Diego 1996).

Materials Disposal/Reuse Study Area

The geology of the individual materials disposal/reuse sites is described below. Beach placement sites are generally cobble to sandy beaches that vary in width, depending on the annual and seasonal variability in the littoral cell coastal processes, as described in Section 3.3 (Oceanography/Coastal Processes).

The *Coast of California Storm and Tidal Waves Study* (CCSTWS) concluded that the future condition of the beaches in northern San Diego County would be governed by cycles of accretion and erosion similar to those of the past 50 years, with accelerated trends toward erosion due to the following conditions: (1) reduction of riverborne sediment due to impoundment by dams, (2) influence of Oceanside Harbor, and (3) increase in the rate of sea level rise (Corps 1991). The EIR/EA for the 2012 RBSP (SANDAG 2011) discusses sediment supply patterns in the Oceanside Littoral Cell. The discussion identified historical sources of sediment for beaches within the littoral cell as bluffs, rivers, streams, and lagoons. However, since the 1950s, dams and construction of Oceanside Harbor have substantially reduced these sediment sources and urbanization has accelerated the erosion rate of coastal bluffs and decreased the rate of sediment reaching the ocean through coastal lagoons. Thus, current sources of onshore littoral material primarily include rivers, bluffs, and artificial fills.

<u>Cardiff</u>

Cardiff State Beach consists of a rocky (cobble) beach that lies on a shallow, wave cut platform. Beach characteristics differ based on seasonal and annual variability, and the beach occasionally becomes stripped of most of its sand from large waves that generally occur during the winter months. Portions of the site have had sand placement in the past as part of beach nourishment projects. Riprap extends along the northern extent of the beach to protect existing commercial buildings (Restaurant Row). The proposed onshore placement site is located directly seaward of San Elijo Lagoon and south of the existing lagoon mouth, extending to the Seaside Parking Lot at the south end of Cardiff State Beach. The nearshore placement site offshore of Cardiff State Beach would be located offshore of the beach within the littoral zone, as described in Section 3.3 (Oceanography/Coastal Processes). The ocean floor at the placement site is predominantly sandy material, and is bounded by hard substrate on the north and south sides. Sand moves through the site naturally, influenced by littoral processes discussed in Section 3.3.

Leucadia

The Leucadia placement site is located on a low terrace, which lies in front of coastal cliffs that characterize Leucadia's beaches. The steep coastal cliffs in this area directly abut the back beach and have been continually forming due to wave action cutting against the marine terrace. The existing placement site comprises the flat, rocky, shallow part of the shoreline visible during periods of low tide.

Moonlight Beach

The Moonlight Beach placement site was formed from sand and rocks that originated from upland erosion. The placement site consists of a relatively thin sand layer, which varies in width and lies on a shallow rock platform. The placement site is relatively wide although beach widths decrease to the north and south, where coastal bluffs line the coast. Sand is placed on this beach by the City of Encinitas and was also a placement site for the 2012 RBSP. Riprap is located at the northern extent of the placement site to protect residential uses.

Solana Beach

The Solana Beach placement site consists of a low tide terrace (wave-cut platform), which lies in front of coastal cliffs south of San Elijo Lagoon. The steep coastal cliffs in this area directly abut the back beach and have been continually forming from wave action cutting against the marine terrace. This process has occurred since the last relative still-stand of sea level, approximately 6,000 years ago (FRH 1997). The proposed placement site received sand from the 2012 RBSP and consists of a variable layer of sand cover over scattered rocks and cobbles visible during low tide in the flat, rocky, shallow part of the shoreline.

Torrey Pines

The Torrey Pines placement site is located on a low tide terrace, which lies in front of coastal cliffs to the north and south of Los Peñasquitos Lagoon. The steep coastal cliffs in this area have been continually forming from wave action cutting against the marine terrace. The existing placement site is characterized by a variable layer of sand cover over the flat, rocky, shallow part of the shoreline visible during low tide, depending on littoral processes and sand placement associated with intermittent inlet maintenance of Los Peñasquitos Lagoon.

Similar to other lagoons in the region, Los Peñasquitos Lagoon was formed in the geologic past when the sea level was lower, the shoreline was farther to the west, and existing streams quickly eroded the exposed marine terraces. Los Peñasquitos Lagoon is an intermittent tidal lagoon due to occasional lagoon closures from sediment accretion at the channel inlet (see also Section 3.3 [Oceanography/Coastal Processes]).

SO-5/SO-6

Marine geophysical surveys and vibracore investigations were conducted at SO-6 and SO-5 for the RBSPs. The SO-6 site is located in the Swami's SMCA offshore of San Elijo Lagoon and extends both north and south of the San Elijo wastewater outfall pipeline. The SO-6 stockpile areas yielded good-quality coarse sand, but contained some areas of hard-bottom areas as well as bedrock. SO-5 is located offshore of San Dieguito Lagoon, in the paleochannel of the San Dieguito River. Marine surveys conducted for the 2012 RBSP indicated that the deepest portion of the paleochannel appears to be in the northern portion of SO-5, with the seafloor texture appearing to be sandy.

LA-5

LA-5 is an offshore sediment disposal site located approximately 6 nautical miles from the San Diego coastline. The site depth ranges from 460 to 660 feet with a 6,000-foot diameter (Corps 2010). The regional seaward features of the San Diego area are a submerged extension of the Peninsular Ranges. The irregular topography of the basins and ridges parallel the structural orientation of the onshore ranges. The mainland shelf seaward of the San Diego Harbor consists mainly of tightly folded late Beogene sandstone and shale, covered extensively with Quarternary sands and muds (EPA 1987). As described in the EIS prepared for the use of the LA-5 location for sediment disposal, samples of bottom sediment were generally sandy-silt and averaged 3 percent gravel, 52 percent sand, 33 percent silt, and 12 percent clay (EPA 1987).

3.5.2 CEQA THRESHOLDS OF SIGNIFICANCE

A significant impact related to geology/soils would occur if implementation of the proposed project would:

A. Expose people or structures to substantial adverse effects involving slope instability/landslides;

B. Result in substantial soil erosion or the loss of topsoil;

C. Expose people or structures to substantial adverse effects involving seismically induced ground shaking causing liquefaction, settlement, ground rupture, or lateral spreading and damage; or

D. Result in the destruction or modification of any unique geologic or physical features.

These CEQA thresholds were derived from a combination of sources, including Appendix G of the CEQA Guidelines and the County Guidelines for Determining Significance for Geologic Hazards.

3.5.3 ENVIRONMENTAL CONSEQUENCES

This section discusses the environmental consequences, or impacts, associated with the proposed project related to geology/soils. Potential adverse, significant, or beneficial direct and indirect impacts are identified as appropriate.

Multiple transportation infrastructure and bridge projects are currently planned within the lagoon. Structural integrity is a critical component for all bridges, and there are engineering standards/codes that dictate design standards and reviewing entities that ensure standards are met. The I-5 bridge widening over the lagoon is proposed by Caltrans and would be implemented as part of the I-5 North Coast Corridor improvements. The double-tracking project through the lagoon is proposed by the LOSSAN Rail Corridor Agency and would be implemented by SANDAG/NCTD. Each implementing agency would perform internal quality reviews of engineering design to confirm that applicable regulatory safety requirements and engineering/building codes are satisfied. Each agency employs qualified experts to perform design and quality assurance. For instance, Caltrans' Division of Design and/or Division of Engineering Services would provide review and approval, as appropriate, for the I-5 bridgework. Improvements proposed to Coast Highway 101 as part of the restoration effort would also be required to meet these engineering design standards/building codes. Coast Highway 101 was part of the State Highway system, but is now under the ownership of the City of Encinitas. Any bridge improvements would be checked for standard/code compliance by the City of Encinitas, at a minimum, and possibly also by Caltrans. All of these entities have professional engineering staff and required review procedures to confirm that engineering/design standards/codes would be implemented for bridge/infrastructure improvements.

Lagoon Restoration

Alternative 2A–Proposed Project

Restoration activities within the lagoon would require the dredging, removal, and backfill of large quantities of material. Approximately 1.4 mcy would be removed from the lagoon basins and tidal channels. The extent of dredging and other ground disturbance for Alternative 2A can be seen in Figure 2-12. The conceptual layout has been prepared to provide adequate hydraulics for the conveyance of tidal and flood flows and varies in dimension depending on the location. Slopes were selected to mimic the current stable shorelines. The currently designed side slopes vary from 5:l (horizontal to vertical) for the larger open channels and overdredge pit, 3:1 for the smaller channels, and 2:1 at the temporary basin and bridge restrictions. Between habitat areas throughout the lagoon basins, slopes would be flatter and vary throughout the lagoon depending on area and geometry.

The overdredge pit has been specifically designed with appropriate distance from the NCTD railroad embankment so that even if the pit unexpectedly collapsed and it assumed a slope equal to its angle of repose, the railroad embankment stability would be unaffected. At the currently designed side slopes of 5:1, there would be a distance of approximately 145 feet from the top edge of the overdredge pit to the railroad embankment toe, and a distance of approximately 350 feet from the overdredge pit toe to the railroad embankment toe. The proposed 2:1 (horizontal to vertical) railroad embankment fill slope would be covered with riprap. The presence of the dredge pit should not cause lateral slope stability or deformation of the 2:1 fill embankment (Ninyo & Moore 2014). If the overdredge pit slope were to become unstable during a strong earthquake, there would be sufficient distance between the overdredge pit and the railroad berm to preclude impacts to the berm from the pit due to the relatively flat 5:1 slope across 350 feet. Thus, the potential for seismically induced lateral spread into the dredge pit is considered negligible (Ninyo & Moore 2014).

Potential for pit slope instability only exists when the pit is empty (i.e., before the pit is filled with dredge material from the lagoon), which would be for a relatively short time of several months. As detailed in the reports prepared regarding stability and geologic hazards related to the LOSSAN Double Track Project (Ninyo & Moore 2012, 2014), a 100-year earthquake event would not be strong enough to trigger significant liquefaction of the on-site soils. However, liquefaction could be triggered by a 475-year seismic event, but, in that event, all train activity on the LOSSAN would stop.

The very low risk of this significant seismic event, combined with the short period when the pit would be empty (2 to 3 months) and adequate distance between the overdredge pit and railroad embankment (to minimize the potential for structural damage if soils were to become unstable), **result in the potential risk for geologic hazards to be reduced to an acceptable level that would be less than significant (Criteria A and C). No substantial adverse impacts would occur.**

Long-term maintenance would include dredging of the inlet and subtidal/sedimentation basin. Adaptive management may result in channel maintenance or refinements in the future. However, no permanent structures would be built in the lagoon. Because the removal and or placement of sediment and other material from the generally flat lagoon basins would not occur in locations that provide stability for other natural features such as slopes or hillsides, the removal of materials for restoration and ongoing maintenance purposes would not create increased slope instability, landslides, or other adverse geologic hazards. No change to existing soil types would result as the project does not involve import of fill materials. **A less than significant direct or indirect impact would result due to increased slope instability, landslides, or other adverse seismic-induced geologic hazards (Criteria A and C).**

Lagoon restoration activities would typically be performed during dry weather conditions but within wet or fairly saturated soil conditions. As dredging would largely be confined to the interior lagoon areas and within the channels, the exposure and potential for erosion would be limited. Dredging activities would occur within areas that have been diked off and flooded to support the water depth necessary for the dredge. This would confine the area of turbidity caused by dredging activities to a limited area and disturbed sediments would have opportunity to settle out within the diked area prior to release of flood waters. Additionally, the type of dredging proposed (hydraulic cutterhead suction) is not the type that generates significant turbidity (such as a clamshell dredge). Further, particularly during construction of the overdredge pit and areas closer to the ocean (west and central basins) material being dredged would have a larger grain size, would settle relatively quickly, and would not migrate to areas of concern (e.g., tidal inlet). For these reasons, turbidity associated with the dredging activities would not be of the magnitude or severity to cause substantial effects. See Section 3.4, Water and Aquatic Sediment Quality, for a discussion of turbidity impacts relative to water quality.

Prior to dredging, the lagoon would be temporarily inundated. This process would not result in high-velocity water flow or other factors that typically cause erosion or sedimentation, and no substantial erosion or other adverse geologic hazards would occur within the temporarily elevated water line. Project-specific permit(s) would be required under the National Pollutant Discharge Eliminations System (NPDES) Permit to the County for the MS4s implemented by the County's Watershed Protection Ordinance (WPO), and to the Regional Water Quality Control Board (RWQCB) for the California Construction General Permit implented by a project-specific Storm Water Pollution Prevention Plan (SWPPP) (PDF-21). The County's permit requires a Stormwater Management Plan (SWMP), a Hydromodification Management Plan, and low-impact development BMPs to eliminate pollutants from leaving the project/construction site and to require project operations to eliminate any added downstream sedimentation or runoff. The state-required SWPPP mandates the implementation of sediment- and erosion-control BMPs in construction and post-construction phases to minimize impacts on surface drainage patterns and the amount of surface runoff.

Also, PDF-22 requires that water levels be actively managed by using a cutterhead dredge and/or temporarily closing the lagoon inlet to minimize release of sediment to the coast, as well as capping the overdredge pit with sand material to encapsulate material and prevent it from being introduced into the water column to minimize release of disturbed material that could cause sedimentation or turbidity.

Wind erosion would be negligible due to the saturated soil conditions, and minor bank erosion (caused mostly by rainfall) would mostly be captured within the lagoon interior tributaries. Natural erosion is an expected process with dredging projects as it contributes to softening the sculpted or scarified surfaces caused by dredging activities. This, along with acceptable sloughing and rounding of underwater contours, would be part of the naturalizing process as the lagoon's affected areas respond and regain a natural appearance following construction. **For the reasons outlined above and with implementation and maintenance of appropriate BMPs and PDFs, erosion and sedimentation potential would be properly managed in the lagoon basin, and direct or indirect geologic impacts would be less than significant (Criteria A and B). No substantial adverse impacts would occur.**

Access roads and staging areas located at the lagoon edges would be on drier upland areas where ground surface disturbance would have a greater potential for erosion. Generally, disturbance associated with upland access roads and staging area preparation and use would include some amount of vegetation clearing, grading, and/or fill with earth and gravel to accommodate construction and maintenance vehicles, equipment, and materials. Ground disturbance in these upland areas with drier soils and more varied topography would be susceptible to wind and water erosion and resulting downgradient sedimentation. However, as described in Section 3.2 (Hydrology), project-specific permits would be required under the County and state NPDES Permits. BMPs would be developed specifically for the conditions of each access road or staging area location, and could include measures such as vegetated drainage swales, requirements to cover and secure earthen stockpiles, use of runoff dissipaters, use of gravel or other ground covers, and other appropriate erosion-control measures (PDF 21). **With the implementation and maintenance of mandated BMPs, erosion and sedimentation potential would be managed in the upland areas, and related direct or indirect geologic impacts would be less than significant (Criteria A and B). No substantial adverse impacts would occur.**

Alternative 2A would improve tidal flow by constructing a new, more stable lagoon inlet south of the existing inlet. A Tidal Inlet Stability Study was prepared for the project to analyze the proposed tidal inlet concept for their stability (M&N 2012c). Based on its findings, the study recommended moving forward with the proposed concept design tidal inlet dimensions for each alternative. As recommended by the study, periodic dredging to remove sand and short and low CBFs have been incorporated into the project for Alternative 2A to increase inlet stability by reducing cobble input into the inlet. As described in Section 2.10.12, a long-term maintenance program is proposed as part of the project and would be included as part of the restoration plan. CBFs would be constructed on either side to block cobble from entering the lagoon to the extent possible and minimize maintenance costs to eventually remove the cobble. These features would also minimize the potential for the inlet to experience substantial erosion due to tidal flow and scouring, and wave-induced scour by blocking direct wave impact on bridge abutments. **CBFs would help to minimize potential erosion-related soil instability and would not create additional geologic hazards. Lagoon water levels would be actively managed by temporarily closing the lagoon inlet, which would minimize released sediment along the coast and allow settlement of materials (PDF-25). Direct or indirect impacts to geologic resources would not be substantially adverse and would be less than significant (Criterion B).**

Under Alternative 2A, a new Coast Highway 101 bridge would be built to span the new inlet location. Construction of this bridge would potentially occur within soil types subject to liquefaction, erosion, settlement, or other unstable geologic conditions, and this would be a potentially significant CEQA impact. Although the bridge would be designed in accordance with applicable current state and federal guidelines that address geologic hazards, seismic codes, geotechnical conditions, and loading criteria (PDF-31), mitigation would be required. Alternative-specific geotechnical studies are required to engineer the final pile and foundation design and establish whether piles would be driven to bedrock. The size and number of piles would be determined at the time of design and could use the friction from the pile surface to counter the loading. Seismic-induced liquefaction would have the highest potential to occur at the bridge abutments, where the fill material next to the bridge could liquefy if not appropriately treated with site-specific measures such as vibro-replacment (rock columns), cement mixing, or installing several shallow piles.

The channel under the new I-5 bridge planned by Caltrans would require substantial deepening for improved hydraulics, and a new NCTD bridge structure would be constructed by NCTD with a channel extending beneath it as part of the LOSSAN double-tracking project. The channel deepening also may enter potentially liquefiable alluvial units, requiring mitigation and armoring at the bridge footings to minimize potential for scour and erosion of the new channel. **Thus, direct or indirect impacts related to the exposure of people or structures to increased risk due to seismically induced ground shaking causing liquefaction, settlement, ground rupture, lateral spreading and damage, or other geologic hazard would result in a potentially significant geologic hazard impact under CEQA (Criteria A and C). No substantial adverse impacts would occur under NEPA due to engineering codes, regulations, and requirements that would be met.**

The lagoon is a unique geologic feature in that it is rare and it is the mouth of Escondido Creek. The topography of the project area, which is the lagoon surface and innundated area, is generally level. Steep bluffs, which also qualify as a unique geologic feature, border portions of the lagoon to the north and south. These bluffs are outside of the construction area and would not be modified or changed by the project. No actions of the project within the lagoon basin would result in adverse changes to the geology or stability of the bluffs. The restoration project includes actions within the lagoon that would enhance the long-term viability of the lagoon's unique geology as a tidally influenced esturary. **A less than significant direct or indirect impact would result (Criteria A and B). No substantial adverse effect would occur to unique geologic or physical features being altered or destroyed through restoration or ongoing maintenance activities (Criterion D).**

Alternative 1B

Similar to Alternative 2A, restoration activities and ongoing maintenance within the lagoon would require excavation of large quantities of material, approximately 1.2 mcy, from the lagoon basins and tidal channels. The extent of dredging and other ground disturbance for Alternative 1B can be seen in Figure 2-13 and conceptual slopes and terrain modification would be similar to that described for Alternative 2A. Also, dredging activities would occur within areas that have been diked off and confine the area of turbidity, the disturbed sediments would have opportunity to settle out within the diked area prior to release of the flood waters, the type of dredging proposed does not generate substantial turbidity, and the type of material being dredged would be of a grain size that settles out of the water column relatively quickly, particularly near the inlet. See Section 3.4, Water and Aquatic Sediment Quality, for a discussion of turbidity impacts relative to water quality.

As with Alternative 2A, an overdredge pit is proposed in the design. The overdredge pit was specifically designed with appropriate distance from the NCTD railroad embankment so that, even if the pit unexpectedly collapsed, the railroad embankment stability would be unaffected. At the currently designed side slopes of 5:1, there would be a distance of approximately 145 feet from the top edge of the overdredge pit to the railroad embankment toe, and a distance of approximately 350 feet from the overdredge pit toe to the railroad embankment toe. The proposed 2:1 (horizontal to vertical) railroad embankment fill slope would be covered with riprap. The presence of the dredge pit should not cause lateral slope stability or deformation of the 2:1 fill embankment (Ninyo & Moore 2014). If the overdredge pit slope were to become unstable during a strong earthquake, there would be sufficient distance between the overdredge pit and the railroad berm to preclude impacts to the berm from the pit. The potential for seismically induced lateral spread into the dredge pit is considered negligible (Ninyo & Moore 2014).

As described for Alternative 2A, the very low risk of this significant seismic event, combined with the short period when the pit would be empty (2 to 3 months) and the adequate distance between the overdredge pit and railroad embankment (to minimize the potential for structural damage if soils were to become instable) **result in the potential risk for geologic hazards to be reduced to an acceptable level that would be less than significant (Criteria A and C). No substantial adverse impacts would occur.**

Because the removal and/or placement of sediment and other material from the generally flat lagoon basins would not occur in locations that provide stability for other geologic formations or natural features such as slopes or hillsides, the removal of materials for restoration and ongoing maintenance purposes **would not create increased slope instability, landslides, or accelerated erosion. A less than significant direct or indirect impact would result (Criteria A and B). No substantial adverse effect would occur.**

Alternative 1B would retain the existing Coast Highway 101 bridge and would seismically retrofit the existing structure due to current seismic safety deficiencies. The bridge retrofit activities would not exacerbate or increase geologic risk, but would reduce risk caused by the existing seismic deficiency of the bridge (M&N 2013). **Final retrofit design for the bridge would be reviewed by appropriate regulatory agencies prior to construction, and would adhere to existing laws and regulations. Impacts would be less than significant as related to the exposure of people to increased risk due to seismically induced ground shaking causing liquefaction, settlement, ground rupture, lateral spreading and damage, or other geologic hazard owing to the Coast Highway 101 bridge retrofit (Criterion C). No substantial adverse impacts would occur.**

Channels underneath the existing Coast Highway 101, I-5, and NCTD railroad bridges would require substantial deepening for improved hydraulics and necessitate appropriate design standards and protection. Analyses conducted for the SELRP indicate that no increase in scour depth would occur under the bridge from channel deepening. This means that channel deepining would occur in materials that are resistant to scouring and that the hydraulics of the channel flow would be stable and non-erosive at its depth. This conclusion is supported by the bedrock sill existing west of the bridge (M&N 2013). The hydraulic analyses of cross-sections of the existing Coast Highway 101 bridge indicate that, for Alternatives 1A and 1B, the hydrology over time would widen rather than deepen the channel to convey greater tidal flow volumes (M&N 2013).

The channel deepening and resulting protection design would be engineered in accordance with applicable current state and federal guidelines that are required to address erosion hazards, seismic codes, geotechnical conditions, and loading criteria. As described at the start of this analysis, each appropriate reviewing entity would review and verify that structural stability standards are met. **Impacts would be less than significant as related to the exposure of people to increased risk due to seismically induced ground shaking causing liquefaction, settlement, ground rupture, lateral spreading and damage, or other geologic hazard owing to channel deepening activities associated with each of the bridges (Criterion C). No substantial adverse impacts would occur.**

Similar to the discussion provided for Alternative 2A, a project-specific SWMP (with a Hydromodification Management Plan and low-impact development) and SWPPP would be developed that mandates the implementation of construction and post-construction sediment and erosion control BMPs (PDF-21). BMPs could include measures such as vegetated drainage swales, requirements to cover and secure earthen stockpiles, use of runoff dissipaters, use of gravel or other ground covers, and other appropriate erosion control measures. **The potential for increased erosion, direct or indirect destruction of a unique geologic or physical feature, or other resulting geologic hazards would not be substantially adverse and would remain less than significant (Criteria A, B, C, and D).**

Alternative 1A

Restoration activities and ongoing maintenance within the lagoon would require excavation of material, approximately 160,000 cy, from the lagoon basins and tidal channels. The extent of dredging and other ground disturbance for Alternative 1A can be seen in Figure 2-14. Because this alternative does not use an overdredge pit and results in the removal and/or placement of sediment and other material from the generally flat lagoon basins, it **would not create increased slope instability, landslides, or other geologic hazards. No substantial adverse impacts**

would occur, and a less than significant direct or indirect impact would result (Criteria A and B).

As described for Alternative 1B, Alternative 1A would also retain and retrofit the existing Coast Highway 101 bridge and would require deepening of channels underneath the existing Coast Highway 101, I-5, and NCTD railroad bridges. The existing bridge structure on Coast Highway 101 would be seismically retrofitted, and existing bridges would need appropriate protection. The bridge retrofit and channel excavations would not exacerbate or increase geologic risk caused by the existing seismic deficiency of the bridge (M&N 2013). Analyses conducted for the SELRP indicate that scour depth would not be increased under the bridge from channel deepening and the cross-section under existing Coast Highway 101 bridge would widen rather than deepen to convey greater tidal flow volumes (M&N 2013). The deepening and resulting protection design would be engineered in accordance with applicable current state and federal guidelines that are required to address geologic hazards and must consider seismic codes, geotechnical conditions, and loading criteria. As described at the start of this analysis, each appropriate reviewing entity would review and verify that structural stability standards are met. **Impacts would be less than significant as related to the exposure of people to increased risk due to seismically induced ground shaking causing liquefaction, settlement, ground rupture, lateral spreading and damage, or other geologic hazard owing to channel deepening activities associated with each of the bridges (Criterion C). No substantial adverse impacts would occur.**

Similar to the discussion provided for Alternative 2A, project-specific SWMP (with Hydromodification Management Plan and low-impact development) and SWPPP would be developed that mandate the implementation of construction and post-construction sediment and erosion control BMPs (PDF-21). BMPs could include measures such as vegetated drainage swales, requirements to cover and secure earthen stockpiles, use of runoff dissipaters, use of gravel or other ground covers, and other appropriate erosion control measures. T**he direct or indirect potential for increased erosion, destruction of a unique geologic or physical feature, or other resulting geologic hazards would not be substantially adverse and would remain less than significant due to implementation of Alternative 1A (Criteria A, B, C, and D).**

No Project/No Federal Action Alternative

The No Project/No Federal Action Alternative would not result in modifications to the lagoon and there would be no adverse change to geologic conditions or resources. **No impact would result (Criteria A, B, C, and D).**

Materials Disposal/Reuse

It is anticipated that material placed as part of materials disposal/reuse could be deposited on existing beaches and the ocean floor, and would ultimately be spread alongshore, cross-shore, and across the ocean floor through natural littoral transport.

The SAP (Appendix A) has been reviewed by EPA and the Corps. Initial SAP work involved analysis of materials for suitability for placement on the beach, in the nearshore zone, at offshore former SANDAG borrow sites and into the proposed overdredge pit in the lagoon for Alternatives 1B and 2A. The analysis indicated that materials excavated from the overdredge pit location (Alternatives 2A and 1B) are likely to be suitable for placement on beaches or in the nearshore. Additional evaluation of the preferred alternative and placement option with these agencies would be required to obtain a final compatibility determination.

Preliminary soil investigations included in the SAP also suggest the material would be suitable for disposal at LA-5 as proposed in Alternative 1A; however, a formal determination from EPA and the Corps would be required prior to disposal. Discussions in the SAP regarding offshore disposal at LA-5 occurred for background and to understand its capacity limitations, but formal submittals requesting authorization to place sand would be made upon selection of a final alternative. If disposal at LA-5 were part of the selected alternative, then supplemental Tier 3 analysis would be required.

Alternative 2A–Proposed Project

<u>Offshore Stockpiling</u>

Seismic activity occurring at offshore locations, such as SO-5 and SO-6, or nearshore at Cardiff would not result in typical geologic hazards generally associated with onshore locations, such as ground failure or liquefaction. Offshore seismic activity would be more likely to result in hazards such as ocean waves or a tsunami, rather than geologic hazards that could directly or indirectly affect people or structures. The placement of materials at offshore locations would not increase or create potential for geologic conditions that could expose people to seismically induced adverse geologic hazards and impacts to seismically induced ground shaking, ground rupture, and liquefaction. **There would be no impact (Criterion C). No substantial adverse effects would occur.**

Sand placed at offshore locations outside the depth of closure (SO-5, SO-6, and LA-5) would not be substantially affected by sand transport processes as described in Section 3.3

(Oceanography/Coastal Processes). **No impacts to slope instability, landslides, or substantial erosion would occur (Criteria A and B). No substantial adverse effects would occur.**

The placement of materials at offshore locations would be below the surface of the ocean and in areas designated for and currently used as materials disposal/placement locations. Thus, no unique geologic feature would be destroyed by offshore materials placement and **no impact would result (Criterion D). No substantial adverse effects would occur.**

<u>Nearshore</u>

People in the nearshore are typically in boats or personal watercraft. The placement of materials on the ocean floor at nearshore locations would not increase or create potential for geologic conditions that could expose people to seismically induced geologic hazards. **There would be no substantial adverse impacts associated with seismically induced ground shaking, ground rupture, or liquefaction at this location. Impacts would remain less than significant (Criterion C) and no substantial adverse effects would occur.**

The addition of structures along the shoreline within a littoral cell can modify littoral processes in that cell, and can affect beach width by increasing erosion or beach sand loss from onshore. To minimize shoreline changes in the vicinity of the new inlet, Section 3.3 (Oceanography/Coastal Processes) discussed the creation of a prefilled ebb bar. Construction of the ebb bar at this location simultaneously with the new inlet would prevent excessive erosion at Cardiff State Beach. The remainder of materials placement is intended to supplement material in the littoral system and would not affect erosion patterns at area beaches. In fact, onshore placement would be a benefit in the near term. **No significant impacts to slope instability, landslides, and substantial erosion are anticipated (Criteria A and B). No substantial adverse effects would occur.**

Similar to the discussion of offshore placement, the placement of materials within the nearshore would be below the surface of the ocean. Thus**, no unique geologic feature would be destroyed by offshore materials placement and no impact would result (Criterion D). No substantial adverse effects would occur.**

<u>Onshore</u>

For proposed onshore materials placement sites, seismic activity associated with the Rose Canyon or other nearby faults may lead to liquefaction, ground failure, sand volcanoes, or seaward slumping of beach material. These conditions exist currently, and the placement of additional material onshore in the proposed locations would not affect these processes. The adverse direct or indirect exposure of people or structures to seismically induced ground shaking causing liquefaction, settlement, ground rupture, or lateral spreading and damage would not be affected by onshore materials placement, and **impacts to seismically induced ground shaking, ground rupture, and liquefaction would be less than significant (Criterion C). No substantial adverse impacts would occur.**

The placement of sand at onshore locations, such as the proposed beach sites, would not cause geologic hazards as a result of ground instability or erosion. Placed material would supplement existing beach material that already exists in these locations. The placement of materials at some onshore locations may reduce the potential for geologic hazards as it would protect against the undercutting or erosion of cliffs or other areas subject to wave-induced erosion, thus reducing slope instability and landslide potential. As discussed in Section 3.3 (Oceanography/Coastal Processes), littoral transport in the Oceanside Littoral Cell causes sand movement onshore/offshore, as well as alongshore, depending on seasonal and annual variations in wave direction and energy. Beaches in the project study area tend to be relatively narrow and backed by bluffs or infrastructure (e.g., roads, restaurants), with slightly wider sand platforms in summer compared to winter. Materials placed at the proposed onshore locations would eventually be moved as part of the littoral cell process but would not increase or accelerate this natural sand transport process. **No substantial adverse impacts to slope instability, landslides, and substantial erosion are anticipated, and impacts would remain less than significant (Criteria A and B)**.

Beaches in the study area are typically overlain by a layer of sand varying in thickness depending on the littoral processes described in Section 3.3 (Oceanography/Coastal Processes). Sand bar thickness in the nearshore areas adjacent to littoral zone placement sites may increase temporarily with the placement of additional material in the system. The material would remain in the mobile overlying layer of the littoral zone and would not affect the underlying geologic characteristics of the region. Material proposed for reuse (e.g., in the location of the overdredge pit in the central basin) has been confirmed to be compatible with existing sand in the system and would not affect the overall characteristics of the littoral cell.

Alternative 1B

Materials placement for Alternative 1B is similar to that proposed for Alternative 2A. Sand placement at area beaches, in the nearshore, and in the offshore, as described for Alternative 2A, could still occur. Material placement would supplement sand already in the system and would not increase erosion along the coastline. Similar to Alternative 2A, **less than significant impacts to geology/soils would occur (Criteria A, B, C, and D). Impacts would not be substantially adverse.**

Alternative 1A

Under Alternative 1A, minimal beneficial reuse of material is anticipated. The majority of material would be exported offshore to LA-5 for disposal with a small volume being reused on-site for the nesting and transitional areas. Material deposited in LA-5 may redistribute slightly over time due to water currents but is anticipated to remain relatively undisturbed due to its depth and location outside of the littoral zone. The placement of materials at LA-5 would be below the surface of the ocean and in an area designated for, and currently used as, a materials disposal/placement location, with no adverse effects to geologic hazards or features. The EIS prepared by EPA for the designation of LA-5 as an ocean disposal site found that the placement of materials at the LA-5 location would not create substantial adverse geologic effects (EPA 1987). While initial testing suggests the material would be suitable for disposal at LA-5, supplemental Tier 3 analysis would be required to verify the material meets criteria for LA-5 disposal prior to approval for placement by EPA and the Corps. **Less than significant impacts to geology/soils would occur (Criteria A, B, C, and D). No substantial adverse impacts would result.**

No Project/No Federal Action Alternative

The No Project/No Federal Action Alternative would not result in nourishment of area beaches or the nearshore. **No adverse direct or indirect impacts to geologic conditions or resources would result, and no positive benefits to the littoral zone with respect to the sand nourishment identified as a component of the RSM Plan would occur (Criteria A, B, C, and D).**

3.5.4 Avoidance, Minimization, and Mitigation Measures

Impacts on geologic hazards from construction of the overdredge pit, tidal inlet, and bridge for Alternative 2A, and overdredge pit for Alternative 1B are less than significant due to project design features and engineering standards/codes that dictate design standards, plus appropriate reviewing entities that ensure standards are met to avoid or minimize geologic impacts.

The following mitigation measures are required for CEQA significant impacts. Mitigation measure Geology-1 would be required under CEQA for implementation of Alternative 2A.

Geology-1 The proposed bridge improvement and channel-deeping portions of the project could result in significant impacts from liquefaction, erosion, settlement, and other unstable geologic conditions. The mitigation of performing geotechnical investigations and implementing site-specific measures recommended in the engineering study to ensure appropriate design for structural stability and reducing unstable geologic conditions is required to reduce impacts to less than significant. After implementation of the measures identified to remediate potentially unstable geologic conditions, certification shall be provided by a California Registered Professional Engineer or Certified Engineering Geologist that states that the measures are in place and the identified liquefaction, erosion, settlement, or other unstable geologic conditions have been adequately remediated to mitigate the potential impact.

Project design features also incorporate project engineering and design measures necessary to meet regulatory requirements and standards to ensure geologic safety. Project design features addressing geologic hazards include implementation of an approved SWMP, Hydromodification Management Plan, and low-impact development BMPs to eliminate pollutants from leaving the project/construction site and to require project operations to eliminate any added downstream sedimentation or runoff, and implementation of a state-required SWPPP for sediment and erosion control BMPs in construction and post-construction phases with BMPs to minimize impacts on surface drainage patterns and the amount of surface runoff. In addition, active management of the tidal inlet to allow for settlement of sediments and minimization of release of disturbed sediment to the ocean, pile and abutment design requirements, and incorporation of recommendations related to sea level rise from SANDAG would be required. Mitigation and project design features have been incorporated throughout the project to minimize and avoid geologic hazards.

3.5.5 Level of Impact after Mitigation

CEQA: Potential impacts related to geology/soils would be mitigated to less than significant.

NEPA: No substantial adverse direct or indirect impacts associated with geology and soils have been identified due to implementation of the SELRP.